Characterization of Essential Tremor in the Major Degrees of Freedom of the Upper Limb

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Introduction: Essential Tremor (ET) is the most common type of tremor and one of the most common movement disorders. It manifests as low-frequency (4-12 Hz) postural and kinetic tremor and is exacerbated by emotion, exercise, and fatigue. In most patients, ET produces a tremor in the upper limbs, making activities of daily living difficult or impossible. Despite its devastating effect on upper limb function, we do not know how ET is distributed throughout the upper limb. Most studies have focused on either a single degree of freedom (DOF) or endpoint tremor. While these methods are useful for reducing the complexity of the problem and focusing on the neurophysiology of ET, they are insufficient for developing optimal treatment options. Using motion capture sensors and surface electromyography (EMG), we are characterizing the severity and frequency of tremor in the major DOFs of the upper limb of patients with ET.

Materials and Methods: Data collection involving patients was performed at the NIH Clinical Center in collaboration with Dr. Mark Hallett, chief of the Human Motor Control Section at NINDS. 25 ET patients consented to participate in the study. Each subject underwent a neurological examination, performed by a board certified neurologist, before participating in the study.

Subjects were evaluated for tremor severity using the TETRAS clinical rating scale, and then were instrumented with surface EMG sensors (Trigno by Delsys) and electromagnetic motion trackers (trakSTAR by Ascension Technologies, Inc.). Fifteen muscles of each subjects' right upper limb were monitored. Motion tracking was completed using five sensors placed on a subject's trunk and right arm.

Testing included a variety of postural and kinetic tasks. Postural tasks required subjects to point at a target for 30 seconds. A total of 7 different targets, corresponding to different postures, were used. For kinetic tasks, subjects were asked to move back and forth between pairs of targets for 30 seconds, for a total of 6 pairs. Each task was repeated three times. Upon completion, the maximum voluntary contraction (MVC) for each instrumented muscle was recorded.

Results and Discussion:

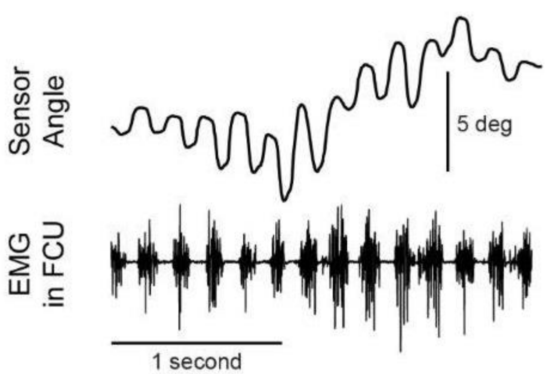

Figure 1. Time-synchronized data from a motion tracking sensor mounted on the hand (top) and an EMG sensor over the flexor carpi ulnaris (bottom), demonstrating the relationship between tremorogenic muscle activity and tremor.

Tremor was successfully measured in the 7 major DOF of the arm (from shoulder to wrist) of 25 patients with ET using motion capture and surface EMG. Inverse kinematics calculations were used to convert motion capture data into joint angles for the 7 DOFs. Surface EMG sensors captured muscle activity in 15 muscles of the upper limb. As shown in Figure 1, some patients exhibited a clear relationship between tremorogenic muscle activity and tremor.

Our main short-term goal is to use these data to characterize the distribution of tremor amplitude, frequency, and phase throughout the 7 DOF and 15 muscles. In addition, we will investigate the variability and existence of patterns between subjects, as well as the exact relationship between muscle activity and tremor.

Conclusions: Combining motion capture in 7 DOF and surface EMG in 15 muscles, we are characterizing the distribution of ET throughout the upper limb, with the end goal of optimizing tremor-suppressing treatments.

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